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ABSTRACT

The American College Testing Program is developing a new program, Work Keys, a system to develop and assess employability skills. It consists of four components: (1) a systematic process for profiling job skill requirements; (2) assessments that measure learners' job skill levels; (3) procedures and formats for conveying assessment results so they will be useful to those receiving them; and (4) instructional resources to assist educators and learners in developing these job skills. The conceptual foundation of the Work Keys assessment system, the development process, and the first developed assessments are discussed. Work Keys assessments embody a new approach to standardized testing, one that combines a primary focus on criterion-referenced achievement with significant aspects of construct-based ability testing. Work Keys development includes specifications development, prototyping, and item construction, followed by content and fairness reviews, and pretesting and construction of operational forms. To date, Work Keys has produced three assessments yielding four scores: "Reading for Information," "Applied Mathematics," "Listening," and "Writing." The Listening and Writing instrument is administered as a single constructed-response assessment and can then be scored for listening, writing, or both. The four assessments are available beginning in September 1992. Five tables give details about test construction. An appendix contains the test descriptions. (SLD)

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Work Keys:

Developing the Assessments

Joyce R. McLarty

American College Testing

IN J. D. West (Chair), Work Keys Supporting The Transition From School To Work. A Symposium presented at the One Hundredth Annual Meeting of the American Psychological Association, August 14, 1992, Washington, D. C.

WORK KEYS: DEVELOPMENT

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Introduction

The American College Testing Program is developing a new program: Work Keys, a system to develop and assess employability skills. It consists of four components: 1) a systematic process for profiling job skill requirements, 2) assessments that measure learners' job skill levels, 3) procedures and formats for conveying assessment results so they will be useful to those receiving them, and 4) instructional resources to assist educators and learners in developing these job skills.

Work Keys development is currently underway as a joint effort by ACT and five charter states: Iowa, Michigan, Ohio, Tennessee, and Wisconsin. Additional states are negotiating for charter status. In addition, ACT has agreements with a number of national organizations in support of Work Keys development and use. These include the American Association of Community and Junior Colleges, the National Association of State Directors of Vocational Technical Education Consortium, and the National Association of Secondary School Principals.

The development of the assessment components for the Work Keys system is foundational to the success of the system since the assessment scores provide the critical link between examinee skills and skills required on the job. This paper discusses the conceptual foundation of the Work Keys assessment system, the development process employed in creating individual Work Keys assessment instruments, and the first four Work Keys assessments.

A Conceptual Foundation for the Work Keys Assessment System

The key challenge in developing the Work Keys assessment system is to provide psychometrically sound scores that can meet the needs of the Work Keys system. Such a score should

1. be readily interpretable as a description of what the examinee can do,
2. be readily interpretable as a description of the skills required by the job,
3. provide information useful to an examinee wishing to improve skills in order to meet job requirements,
4. provide information useful to an educator or trainer wishing to assist examinees to improve their job skills,

5. be appropriate for large-scale use,

6. be appropriate for validation for use as part of a system for selecting qualified job applicants for hire, and

7. be economically feasible to generate.

In order to meet these criteria, it was necessary to develop Work Keys assessments in a very different way from that generally used in traditional standardized testing. As a result, Work Keys assessments are not simply traditional tests developed for new skill areas. Rather, they embody a new approach to standardized testing; one perhaps best described as combining a primary focus on criterion-referenced achievement with significant aspects of construct-based ability testing. This melding of approaches was necessary to retain the content basis for score interpretation while providing for a hierarchical score scale that would support examinee development.

This combination is basically a Guttman scale approach to test development, scoring, and scaling. In this approach, the test content at each level builds on the content at previous levels, and mastery of each level indicates that all previous levels have also been mastered. Thus, the levels represent a cognitive growth scale rather than collections of skills and information that happen to increase in difficulty. The primary dimension of these criterion-referenced measures is, therefore, the cognitive one. For example, in mathematics, the levels of the test reflect ability to solve increasingly complex mathematical problems rather than the accumulation of additional mathematical techniques and formulas.

While this development approach somewhat resembles the factorial approach sometimes used in creating cognitive ability tests, Work Keys assessments are unabashedly achievement oriented and include only skills that can be taught. Thus, while a Work Keys score describes an individual's current level of "ability" to perform a skill, this level forms a floor with respect to performance, not a ceiling. Work Keys assessments are designed to assist individuals in attaining the job skills they need for the jobs they want, not simply to guide them toward jobs for which they are already qualified.

Unlike cognitive ability tests, the Work Keys assessments focus on comparing the skills of each individual examinee with those required for the job or job family to which that individual aspires (criterion-referencing). Therefore, score comparisons made among individuals can be expected only when several are applying for the same job. Such comparisons would be made by the prospective employer across individuals in the applicant pool, rather than to some kind of national norm group. In the Work Keys system, skills are identified as deficient only as discrepancies between the skills the individual examinee has and the skills required for the job to which that examinee aspires.

Although it is possible to set performance standards on the Work Keys scale, as it is with any criterion-referenced assessment, ACT has not done so. Since the appropriate level of such standards depends on the use to which they are put, it is likely that different standards will be set on the Work Keys assessment for different purposes.

Selection of Skills to Assess with Work Keys

The first step in designing the individual Work Keys assessments was to identify the workplace skills to be covered. A review of the literature and current related projects yielded a listing of the generic skills generally considered important to workplace success (see Table 1). This initial listing was shared with several advisory panels in Work Keys charter states in order to elicit guidance as to which of these skills should be assessed in the Work Keys system and then to establish priorities among the skills to be included. Separate ratings by business and education members of the panels resulted in only slightly different rankings of the skill areas as shown in Tables 2 and 3. The clear priority given to assessing "people/personal" skills by both business and education is apparent in the rankings: Interpersonal/Teamwork and Motivation were in the top three rankings. Ability to Learn, conceived in Work Keys as a set of skills rather than a measure of innate ability, was the third of the subset of skills routinely selected as the most critical to be measured in Work Keys. Based on this input and on an analysis of the likely difficulty in developing each assessment, ACT generated proposed timelines for developing 11 Work Keys assessments (see Table 4).

Insert Tables 1-4 about here

In addition to consideration of the skills to measure, the Guttman-scale approach requires Work Keys to integrate score scale considerations into the test development process. Work Keys development must also ensure the following:

1) The skill is assessed in a manner that is generally congruent with the way the skill is used in the workplace.

2) The lowest level on the assessment is set at approximately the lowest level for which a business would bother setting a standard.

3) The highest level on the assessment is set at approximately the highest level that would be required for an entry-level job.

4) The steps in between the lowest and highest levels are large enough to be distinguished and small enough to be meaningful.

Selection of Formats for Administration

Four assessment formats for Work Keys skills are planned: group-administered assessment, computer adaptive assessment, performance assessment, and self-assessment. Although the primary focus of this paper concerns the group-administered format, it is anticipated that Work Keys assessments will be made available in multiple formats to support coordinated use of different assessment approaches.

Development of group-administered assessment formats is a priority task for Work Keys because it provides assessment instruments that can be used immediately for larger groups of examinees and result in scores appropriate for a wide variety of uses (both low- and high-stakes).

The term *group-administered* refers to a format in which a group of examinees is presented with a uniform stimulus auditorially, visually, or both and each examinee responds individually (i.e., without interacting with others or with the administrator). In order to ensure reliable scores suitable for large scale use, group-administered Work Keys assessments will also require a separately scored response trace. This response trace may be in one of several formats (e.g., marking bubbles on an answer sheet, taking notes, writing an essay, drawing a picture) depending on the requirements of the specific skill. Non-written means of creating a response trace (e.g., audiotaping and videotaping) will be used for some of the Work Keys assessments. For example, the speaking assessment will require a response trace in an audio format. The use of a response trace permits central scoring and rescoring, a key factor in assuring that scores are reliable and that comparable examinee performances receive the same score.

Context for Work Keys Assessments

The intended purposes of the Work Keys assessments and the nature of the Work Keys skills provide a considerable amount of guidance as to the content appropriate for the assessments. It is necessary to include content that addresses the specific Work Keys skills at the appropriate levels. The question of context is less straightforward. In order to maximize the validity of the assessment, it is important that the context of the assessment items be related to the workplace. But which workplace? With literally thousands of workplace contexts to represent, it is not reasonable to create a separate assessment for each one. Even addressing general types of workplace context (e.g., service, manufacturing) would result in a prohibitively large number of assessments. To the extent that the context interacts with the content of the assessment, such assessments would not yield equivalent scores. As a result, an examinee with Level 5 skills in reading on the service-oriented assessment might not have Level 5 skills on the manufacturing-oriented reading assessment, even though both assessments were designed to assess the same skills and skill levels.

Alternatively, it would be possible to substantially remove contexts from the assessment items resulting in a "generic" assessment of the skills. This approach tends to make the assessment more theoretical and less appropriate for an assessment system designed to focus on application of skills.

It was decided, therefore, to (1) sample from a wide variety of workplace contexts, and (2) employ the contexts in such a way that specific knowledge of that context would not be required to respond correctly to the test item. In this way, the assessment as a whole would not tend to advantage or disadvantage an examinee with knowledge of one specific workplace context but not another. It remains true, however, that an examinee who is familiar with a range of workplace contexts may have some advantage over the examinee with no workplace experience, both on the assessment and on the job. Because both the score and the job performance would be enhanced, this effect seems unlikely to reduce the validity of examinee scores.

Because Work Keys uses workplace contexts but does not require prior examinee knowledge of a specific workplace as the basis for responding correctly to the item, development of Work Keys assessments poses several special challenges. The contexts must be described in sufficient detail to make them realistic, but the context descriptions must be carefully limited to avoid making the assessments into reading tests. For example, while vocabulary appropriate to the workplace must be used, it must not interfere with the ability of an examinee who does not know the jargon to demonstrate the skill. Conversely, in depicting workplace contexts, it is critical not to misrepresent the nature of the workplace in a way that would confuse or mislead an examinee who is very familiar with that workplace. Therefore, the development process must include checks on the accuracy and appropriateness of the context, as well as the content, of the assessment items.

The Work Keys Development Process

The development process for group-administered Work Keys assessments may vary somewhat for individual skill areas but always includes the following seven steps:

1) specifications development,
2) prototyping,
3) item construction,
4) content review,
5) fairness review,
6) pretesting, and
7) construction of operational forms.

Although there is a general temporal order to these steps, in some cases they are repeated, telescoped, or reordered.

Specifications Development

Work Keys staff developed the initial skill descriptions for the first Work Keys instruments. These took the form of a general content description for the assessment as a whole together with descriptions and sample items for each skill level. The requirements of Guttman scaling dictate a relatively narrow construct to be measured (so the resulting score scale will be hierarchical for most examinees) and a fairly wide range of content difficulty so performance levels can be clearly distinguished. In developing this type of assessment, one begins by identifying discrete and hierarchical skill levels for each skill, then constructs the items for each level of that skill to contain well-defined and relatively homogeneous content. For this reason, arriving at clear and appropriate definitions of the individual skill levels as well as of the general construct is critical.

Business representatives and entry-level employees from charter states were asked to indicate whether these descriptions and items represented a skill required on entry-level jobs, whether the low and high ends were at appropriate levels, and whether the step-size between levels was useful. The skill descriptions were then adjusted on the basis of their responses. This review and revision of specifications was later repeated based on results of the prototype assessment (described below).

For the remaining instruments, Specifications Development Panels composed of business people and educators from the charter states create the initial descriptions with Work Keys staff developing sample items based on suggestions from the Panels. These descriptions will be widely reviewed in the Charter States and elsewhere, and revised based on that input.

In addition to soliciting judgmental reviews of the assessment and level descriptions, Work Keys staff evaluated materials supplied by cooperating businesses to determine the kinds and levels of skills likely to be required on various jobs and studied job analyses conducted by others for a variety of purposes. Neither type of material was particularly helpful. Both lacked the level of detail necessary to accurately interpret the nature and level of the skill demands of the job. The materials supplied by businesses generally lacked the detailed contextual information that would have distinguished skills needed on entry from those likely to be taught on the job, indicated how critical it was for new employees to be able to perform specific tasks, and described alternative means of learning the required skills that might be available to the employees. Most of the job analyses examined were conducted for human resource purposes, often for job classification or salary studies, and most were task rather than skill based (i.e., focused on the task to be performed, its criticality, and perhaps the conditions under which it had to be done) and, as a result, did not provide

sufficient information to describe even the specific skills required, let alone the specific levels of the skill.

A few job analyses did employ levels, but these also did not prove particularly well suited to assessment development requirements. For example, the New York analysis ("Report to the Board of Regents," 1990) used Bloom's cognitive taxonomy (1956) to index skill level requirements, determining that certain jobs required "understanding," "analysis," or "evaluation" with respect to a skill (e.g., reading). Cognitive taxonomies such as these tend to provide a somewhat shaky basis for test construction because a cognitive level represents an interaction between the examinee and the test materials; what is "analysis" for one examinee may be "knowledge" for another. The more heterogeneous the examinee population, the more likely it is that cognitive specifications alone will be inadequate for test construction purposes.

For this reason and because content descriptions seemed likely to provide the most comprehensible linking mechanism between job requirements and examinee skills as required by the Work Keys system, it was critical to base specifications jointly in both the content and cognitive domains. Accordingly, the Work Keys specifications encompass characteristics of both the stimuli and the questions to be asked on both a cognitive and content level as a single, albeit multifaceted, dimension not unlike those found in many behaviorally anchored rating scales.

For example, in the Work Keys reading assessment, the complexity of the passage and the items will be kept similar; it is not acceptable to ask simple questions about a complex passage. This constraint helps to ensure that when a reading passage is developed for a higher level on the reading assessment, all aspects of it will be at a consistently high level. The content and language of the passage will be complex, and so will questions asked about it. Developing Work Keys assessment items, therefore, becomes challenging in its own right, and this in turn entails a fairly thorough development process.

Prototype Assessments

Because each Work Keys assessment represents development of a new skill area, and because of the complexity of the assessment materials that must be developed, it is necessary to begin by developing exemplar test materials to help solidify the construct and communicate its nature not only to Work Keys charter states, but to others assisting with Work Keys development (e.g., item writers). Accordingly, the development of each new skill area begins with production of a single full-length instrument. Although Work Keys staff writes many of the prototype items, contracted item writers are used as well. This allows staff to determine the best method of communicating item-writing requirements to others and develop the necessary item-writers' guides and other support materials.

Prototype assessments are administered on a small-sample basis in two locations, one in each of two different states, to both entry-level employees and high school students. Sites are selected on the basis of willingness to provide the necessary support for the prototyping process (i.e., on a convenience basis). Each prototype assessment is administered by the responsible Work Keys staff members, who then discuss the assessment with the examinees to get direct and immediate feedback on examinee perceptions of and problems with the format and items. In addition, business people and educators at the sites review the prototype assessment and provide feedback on it to staff members. The prototype sessions are analogous to "alpha testing" in that they provide a first screen to identify any major problems with the new assessment. The examinee and reviewer samples are not large enough or representative enough to provide a statistical basis for decision making. However, the qualitative information gained supports and guides revision of the skill and level descriptions, makes the assessment more congruent with those descriptions, improves item content and format, and allows Work Keys to address any potential administration or scoring problems.

Item Construction

Item construction for Work Keys is contracted to individual item writers selected and supervised by Work Keys staff members. Item Writers' Guides are prepared to provide written directions for those constructing the actual items, and when appropriate, item writers are also provided "hands-on" training by Work Keys staff members. Selection of item writers is based on recent experience with the relevant Work Keys skill in an entry-level job environment and on writing skills.

Once items are received, Work Keys staff evaluates them and returns them for revision or accepts them "as is." Once materials have been accepted, staff members evaluate their fit to item and content specifications, make additional revisions as needed, and enter the materials into electronic format. These materials are then reviewed by an editor and at least one other assigned Work Keys staff member for content accuracy, item quality, consistency of style and format, and clear and appropriate use of language.

When all materials are ready, the Work Keys staff prepares camera-ready assessment booklets (or the equivalent; for example, scripts for the Listening and Writing assessment). These are full-length assessment instruments. Any required administration guides, answer documents, and other pretest auxiliary materials are also prepared.

Content Review

A content-qualified curriculum expert reviews each prototype assessment to help identify any possible mismatch between the assessment and level descriptions and the actual test items on the prototype assessment.

Content-qualified volunteers from charter states review all pretest materials. This review takes place during the development process and may be repeated for any final forms materials that are revised or for which questions arise. Each charter state identifies potential reviewers who are knowledgeable of the Work Keys skill areas under development and of the entry-level job context considerations. A Content Reviewer's Guide provides structure to the review process.

In addition, a content-qualified, experienced test reviewer external to ACT reviews each operational form. Work Keys staff evaluate and respond to any concerns raised by content reviewers and may request additional content reviews for specific materials if they are needed.

Fairness Review

Each charter state identifies potential reviewers with specific knowledge of and experience in reviewing for fairness on the basis of racial, ethnic, gender, age, disability, and other concerns. These qualified volunteers from the charter states review all pretest materials for fairness. This review takes place during the development process and may be repeated for any final forms materials that are revised or for which questions arise. A Fairness Reviewer's Guide provides structure to the review process. Work Keys staff members evaluate and respond to any concerns raised by fairness reviewers and may request additional fairness reviews for specific materials if they are needed.

Pretesting

Pretesting is conducted in all charter states with the required sample divided among them. Both education and business sites are used. Work Keys staff members work with assigned personnel from the charter states to identify sites, coordinate schedules, answer questions, and ensure a smooth and effective pretesting effort. Scoring of pretest materials is handled by ACT directly or contracted as dictated by staff availability and assessment needs.

Data analyses are planned individually for each pretest to ensure the specific needs of the instrument under development are met. Where possible, both classical and IRT approaches to item analysis are conducted. In addition, special item analysis procedures appropriate to Guttman scale considerations have been developed and are employed. Speededness and differential item functioning (DIF) analyses are also conducted where sample sizes permit to help guide data interpretation and the construction of operational forms. All item analyses are repeated using operational data to detect any changes in item characteristics from pretest to operational use.

Operational Forms Construction

When an assessment must be administered more than once to the same examinee, when there is the possibility that information about the assessment may be conveyed to an examinee prior to the assessment (e.g., by another examinee), or when assessment-related activities (e.g., coaching on specific tasks) may affect the interpretation of scores on the assessment, it becomes necessary to provide multiple forms of the assessment. These forms contain different stimuli and questions but are equivalent to the base (original) form in content and psychometric qualities. The usual equivalence criterion is that it should be a matter of indifference to the examinee which form is administered to him or her. The production of additional equivalent forms, however, is not a matter of indifference since alternate forms are difficult and expensive to produce. Not only must new materials be developed, but they must be evaluated to ensure the new forms will produce scores equivalent to those on the base form.

For Work Keys group-administered assessments, a classical approach to equating operational test forms will be used. This provides the maximum control over nonequivalence of score scales due to residual differences in assessment items (e.g., difficulty, discrimination) and to item interaction effects. Once maximally equivalent operational forms have been constructed, these forms are administered following a well-specified research design (e.g., randomly equivalent groups) that will provide data to generate equivalent (equated) scaled scores from them. However, where traditional equating focuses on the equivalence of each score point from one form to the other, in this case the focus will be on the equivalence of level mastery across forms. Alternative item-based (IRT) approaches consistent with Guttman Scaled assessment are currently being explored for use with the computer adaptive Work Keys formats.

Preparation of Additional Forms

The number of forms needed for an assessment depends primarily on the use to be made of the assessment. If any retesting is scheduled within a short period of time, two equivalent forms are usually the minimum requirement so the retested examinee may be administered an alternate form. This approach is preferred also when pre- and post-testing must be done over a relatively short period of time (e.g., for program evaluation) or when testing is of a high-stakes nature (e.g., scores being used to make hiring decisions). Work Keys has already prepared two forms of each of its first group-administered instruments and will continue to develop additional forms as they are needed.

Since embedded pretesting (i.e., embedding pretest items into operational test forms in order to generate the pretest data needed to build additional forms) provides the most accurate pretest data, Work Keys will use this approach whenever it is feasible. Individual items being pretested are placed within operational tests for data collection purposes.

Because each operational form can support only a few additional embedded items without becoming excessively lengthy, a significant number of pretest versions will be created for each operational form. This will allow the Work Keys assessments to become a self-renewing resource providing for ongoing development of high-quality equivalent forms.

The Work Keys Products

To date, Work Keys has produced three assessments yielding four scores: Reading for Information, Applied Mathematics, Listening, and Writing. The Listening and Writing instrument is administered as a single constructed-response assessment and can then be scored for listening, writing, or both. More extended descriptions of these tests and sample items are presented in the Appendix. Number of items and required administration times are included in Table 5.

Insert Table 5 about here

The Reading for Information test measures the examinees' abilities to read and understand work-related instructions and policies. The reading selections and questions are based on the actual demands of the workplace. Selections are in the form of memos, bulletins, notices, letters, policy manuals, and governmental regulations.

The assessment contains questions at five levels of difficulty, with Level 3 being the easiest and Level 7 being the most difficult. The reading selections are arranged from the easiest level to the most difficult. Each selection is followed by one or more multiple-choice questions.

The Applied Mathematics assessment is a test of mathematical problem-solving that focuses on mathematical reasoning skills generally required in the workplace. The assessment questions draw out examinee skills in setting up and solving word problems. This assessment is designed to be taken with a calculator. As on the job, the calculator serves as a tool in the process of problem solving. A formula sheet that includes, but is not limited to, all required formulas is also provided. The assessment contains questions at five levels of difficulty with Level 3 being the easiest. Higher levels of difficulty assume the examinee is knowledgeable of the skills assessed at lower levels.

The Listening and Writing assessment measures two distinct but related skills - listening and writing. Both skills are assessed in one test because the skills are used together in the workplace. The assessment is administered via an audiotape which contains all directions and messages. A variety of speakers read the messages. Each message is read

twice with time given between readings for note taking. Space is provided in the answer booklet for notes; however, the notes are not scored.

After the message is read a second time, the examinees have a specified time to write the message before the next message is read. Examinees may go back and work on earlier messages if they have time. Written messages are scored for listening based on the accuracy and completeness of information that the examinee has included. The writing is evaluated separately, by a different scorer, based on the quality of the writing sample itself, not on its specific content.

These group-administered Work Keys tests are available for purchase beginning in September, 1992.

References

Bloom, B. B. et. al. (1956) Taxonomy of educational objectives: Handbook 1: cognitive domain. New York: McKay.

Report to the Board of Regents on career preparation validation study. (1990) New York State Education Department, New York.

Table 1

Curriculum/Learning Modual Review of Workplace Skills

	CREATIVE THINKING	DECISION MAKING	PROBLEM SOLVING	MENTAL MODEL BUILDING (VISUALIZES)	LEARNING TO LEARN ABILITY TO ACQUIRE KNOW	READING	WRITING	MATHEMATICS	SPEAKING	LISTENING	REASONING	MATURITY EMOTIONAL APPROPRIATE	SELF-ESTEEM	SOCIABILITY-PLEASANT ATTITUDE	COOPERATION (TEAMWORK)	RELIABILITY/ DEPENDABILITY	ORGANIZING	LEADERSHIP/ PERSUADE	NEGOTIATION	TEACHES	TRANSFERABILITY	TOLERANCE OF OTHERS	SERVICE MENTALITY	OBSERVATION NON-VERBAL	MEDIATING	LOCATING INFORMATION	COMPUTER	GOAL SETTING/ MOTIVATION	SELF ASSESSMENT	CAREER DEVELOPMENT	CHALLENGE AUTHORITY	EVALUATION	ANALYSIS	GRAPHS/TABLES	MECHANICAL FORCE, ENERGY, ETC	SAFETY SKILLS	TIME MANAGEMENT
SECRETARY'S COMMISSION ON ACHIEVING NECESSARY SKILLS (SCANS)	E X	E X	E X	E X	E X	E X	E X	E X	E X	E X	E X	E X	E X	E X	E/F X	F X	F X	F X	F X	F X		F X	F X	F X			F X			F X							
COOPERATIVE 2 ASSESSMENT OF EXPERIENTIAL LEARNING (CAEL) INTERPERSONAL SKILLS	X	X	B X							B X			X			X	B X	B X	B X	B X	X				B X	B X										
CARNEVALE WORK PLACE BASICS INTERPERSONAL SKILLS	X	X	X	X	X	X	X	X	X	X	X	B X	B X	B X	X	X	X	X				B X	B X		B X		X	X	B X	X						
APPLIED COMMUNICATION IOWA DEPT OF ED	X	X	X		X	X	X		X	X		X		X	X		X	X			X			X		X						X	X			
CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT MATH/ BIOMED/CIVE/'88 ROBOTICS/'88 SAFETY NUCLEAR TEAM CORD								X																		04X	X							04X		
*AGENCY FOR 3 INTELLECTUAL TECHNOLOGY LEARNING MODULES/AIT	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X		X			X		X			X					X		X	X	X
WORKING SKILLS 3 FOR A NEW AGE VOC ED TEXTBOOK (IA)		X	X			X	X	X	X	X							X								X	X						X		X		
IDENTIFICATION OF GENERALIZABLE SKILLS IN SECONDARY VOCATIONAL PROGRAMS ILLINOIS STATE BOARD OF ED)				X		X	X	X	X	X	X	X		X	X	X	X	X		X		X				X	X					X		X		
PERCEPTION OF 1 B.S INDUSTRY BASIC SKILLS NECESSARY FOR SUCCESSFUL EMPLOYMENT COMPARED TO COMPETENCIES OF ENTRY LEVEL JOBS ILLINOIS			X			X	X	X	X	X	X	X									X															
OFFICE ED 3 CURRICULUM GUIDE SERIES TEXAS						X	X	X										X								X	X							X	X	
AMERICAN COLLEGE TESTING CAREER PLANNING 3 SERVICES STUDY POWER		X	AGE K 12			ACD X K 12 X	ACD X K 12	ACD X K 12	ACD X COLL COMP		ACD X K 12						X				X K 12 COLL COMP			X COMP		X											X
THE CONOVER PROCESS TERRY SCHMIDT PRES (WISCONSIN BASED) 3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X				X	X	X	X							X
ELECTRONIC SELECTION SYSTEM ESS CABOT JAFFEE		X	X	X		X		X		X					X	X							X	X					X							

*Sending more materials
1=No module development
2=Limited development (nothing further planned)
3=Development of skill modules continuing

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Table 2

Overall Mean Importance Ranking for Work Keys Assessments

(N=69, IA, MI, OH, and American Vocational Association)

Work Keys Assessment	Overall Mean Ranking	Business Mean Ranking	Education Mean Ranking
Interpersonal/Teamwork	2.39	2.26	2.57
Ability To Learn	2.71	2.63	2.83
Motivation	3.42	3.68	3.13
Oral Communication	4.16	4.14	4.19
Listening	4.22	3.78	4.78
Solve Scheduling Problems	4.81	4.40	5.18
Reading For Information	4.83	5.18	4.50
Leadership	5.00	5.33	4.79
Composing Written Communication	5.04	5.30	4.87
Mathematical Problem Solving	5.74	5.33	6.25
Looking Up Information	5.79	5.29	6.50
Mechanical Problem Solving	5.88	4.25	7.50
Mathematical Problem Solving/Calc	6.40	6.00	6.60
Completing Forms	6.55	5.50	7.80
Viewing	6.67	5.67	7.17
Editing In English	8.00	7.75	8.20
Analyze Formal Systems	8.90	6.60	11.20

Note. Small means indicate higher average ranking.

Table 3

Overall Frequency of Endorsement for Work Keys Assessments
(N=69, IA, MI, OH, and American Vocational Association)

Work Keys Assessment	Overall Frequency	Business Frequency	Education Frequency
Ability To Learn	94	58	36
Interpersonal/Teamwork	83	49	34
Motivation	74	41	33
Oral Communication	64	38	26
Reading For Information	63	34	29
Listening	60	34	26
Mathematical Problem Solving	44	25	19
Composing Written Communication	43	19	24
Solve Scheduling Problems	40	19	21
Looking Up Information	31	17	14
Leadership	30	14	16
Mechanical Problem Solving	25	16	9
Mathematical Problem Solving/Calc	19	9	10
Completing Forms	14	9	5
Analyze Formal Systems	14	8	6
Viewing	14	7	7
Editing In English	11	5	6

Note. Large numbers indicate instrument endorsed by more people. Frequency data includes TN and WI.

Table 4

Proposed Timetable for Releasing Work Keys Assessments

Year	Assessments Released
1992	Reading for Information
	Applied Mathematics
	Listening and Writing
1993	Teamwork
	Locating Information
	Applied Technology
1994	Motivation
	Observing and Speaking
	Ability to Learn

Note. Titles of 1993 and 1994 assessments may change.

Table 5

Number of Items and Minutes Allowed for Work Keys Assessments

Test Type	Part 1 Items	Part 1 Time	Part 2 Items	Part 2 Time
Reading for Information	33	40 minutes	24	40 minutes
Applied Mathematics	33	40 minutes	22	40 minutes
Listening/ Writing	5 or 6	35 minutes	4	35 minutes

APPENDIX

Work Keys Test Descriptions

WORKKEYS

Test Descriptions

- Reading for Information
- Listening & Writing
- Applied Mathematics

ACT

ACT endorses the *Code of Fair Testing Practices in Education*, a statement of the obligations to test takers of those who develop, administer, or use educational tests and data. The *Code* sets forth criteria for fairness in four areas: developing and selecting appropriate tests, interpreting test scores, striving for fairness, and informing test takers. ACT is committed to ensuring that each of its testing programs upholds the *Code's* standards as they apply to test developers.

A copy of the full *Code* may be obtained free of charge from ACT Publications, P.O. Box 168, Iowa City, Iowa 52243, 319/337-1429.

WORKKEYS

Reading for Information

Test Description

The Reading for Information assessment measures the examinee's ability to read and understand work-related instructions and policies. It is designed to be taken by current employees and potential employees in a variety of businesses. The reading selections and questions are based on the actual demands of the workplace. Selections are in the form of memos, bulletins, notices, letters, policy manuals, and governmental regulations.

The test contains questions at five levels of difficulty with Level 3 being the easiest. The reading selections are arranged by level from easiest to most difficult. Each selection is followed by one or more multiple-choice questions.

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Level 3

At this level, the reading passages are short and uncomplicated with basic vocabulary. The passages deal with simple company policies, procedures, and announcements. The information needed in order to answer the questions is clearly stated in the passage, and the questions focus on the main points of the passage. The wording of the questions and answers is very similar to the wording used in the passage. A typical question would ask the examinee to recognize the next step in a sequence of actions or to recognize the proper time to perform a task.

Example:

MEMO

To: Juanita Fuentes, Roger Schmitz, and Marvin Stone

From: Pola Antebi

Re: Committee Meetings

I have made the room reservations for our committee meetings. The budget committee will meet in the Lansing Room. The personnel committee will meet in the Marsillon Room. The marketing committee will meet in the Tullahoma Room. The planning committee will meet in the Platte Room. The meetings will start at 9:00 A.M. and end at 12:00 P.M.

Where will the marketing committee meet?

A. The Lansing Room
B. The Marsillon Room
C. The Tullahoma Room
D. The Platte Room
E. The Antebi Room

Level 4

At this level, the reading passages are longer and more complex. The policies and procedures are more detailed and have a greater number of steps. Many passages describe policies and procedures where, depending on various factors, appropriate behavior changes. In this example, the passage describes two possibilities for the placement of salt and pepper shakers after an employee wipes a table. If the shakers are more than half full, they are returned to the table. If the shakers are less than half full, they are left on the cart.

At Level 4, the questions and answers may be paraphrased from the passage rather than taken verbatim. Furthermore, while the vocabulary used is still elementary, the passages contain words that are more difficult than those at Level 3. In this example, the word "reposition" is used, whereas at Level 3 the phrase "put back" would have been used. Likewise, in the sample passage the word "disinfect" is used, whereas at Level 3 the phrase "kill germs" would have been used.

Example:

After lunchtime is over, push your cart to each of the tables in the cafeteria. Be sure to have your sponge with you. At each table, remove the salt and pepper shakers and place them on your cart while you wipe off the table with disinfectant. If the shakers are more than half full, reposition them on the table after you have finished wiping the table. If the shakers are less than half full, leave them on your cart and go to the next table. At the next table, repeat what you did at the first table. Keep going until all of the tables have been disinfected. When you have disinfected all of the tables, take your cart and the empty shakers to the kitchen.

After lunchtime is over, what should you do if a salt shaker is less than half full?

A. Leave it on the table until after the dinnertime is over.
B. Leave it on the table until it is completely empty.
C. Take it to the kitchen by hand after cleaning the tables.
D. Take it to the kitchen on the cart as soon as you see it.
E. Take it to the kitchen on the cart after cleaning all the tables.

Level 5

At this level, both the passages and the questions are more difficult than at the previous level. The passages are more detailed, more complex, and cover broader topics than those at Level 4. In this example, the passage describes various characteristics of two delivery services. The vocabulary used in the passage includes words and phrases that may be specialized, such as "overnight services," or that have multiple meanings, such as the word "serve."

The questions typically call for applying information given in the passage to a situation that is not specifically described in the passage. In this example, the question following the passage describes a specific situation that is not described in the passage. All the information needed to answer the question is clearly stated, but the examinee must take into account several considerations in order to choose the correct response.

Example:

DRG Industries, Inc. uses two overnight services: Quick Delivery Services and Overnight Mail Services. Quick Delivery Services makes deliveries Monday-Friday. This service has no weight limit for packages, and it guarantees that items will be delivered before 10:30 A.M. However, they will not make deliveries on weekends or holidays. This is a new company, and it only delivers to major cities. If you decide to use Quick Delivery Services, bring your package to the mail services department by 2:30 P.M. on the day it should be sent.

If you decide to use Overnight Mail Services, you can bring your package to mail services as late as 5 P.M. This company can deliver packages of up to 50 pounds. It serves large cities and most towns, but you must have a street address. Packages are delivered between 10:30 A.M. and 1 P.M. Overnight Mail Services will not deliver on weekends or holidays.

On Wednesday, you are given a large box that needs to be delivered overnight to Chicago. In choosing what mail service to use, which of the following would be the deciding factor?

A. Destination of the package
B. Day of the week it is sent
C. Cost using the mailing department
D. Weight of the package
E. Contents of the package

Level 6

At this level, the policies and instructions are significantly more difficult than those at the previous level. The presentation of the information is more complex; passages may include excerpts from regulatory and legal documents. The procedures and concepts described are more elaborate. Advanced vocabulary, jargon, and technical terms are used. Most information needed in order to correctly answer the questions is **not** clearly stated in the passage.

The questions call on the examinee to generalize beyond the stated situation, to recognize implied details, and to recognize the probable rationale behind policies and procedures. In this example, the classification of polypropylene is never directly stated, but it is possible to determine this classification from the passage.

Example:

(Excerpt)

Synthetic carpeting is flame resistant, but the carpeting can melt and fuse if it is exposed too long to temperatures above 500° F, such as those from a burning cigarette. The fused spot will be a noticeably different color because it will be more resistant to wear. Synthetic fibers are resistant to insect infestation and fungal growth, such as mold and mildew, because the fibers are not organic. Some synthetic carpets resist dirt more effectively than others. For example, nylon attracts more soil particles than polypropylene or acrylics. Polypropylene and acrylics are also resistant to staining. Unlike synthetic carpeting, wool carpeting will burn, but the damage caused by lit smoking material is not usually as deleterious, partly because the charring is easier to remove. Because it contains organic materials, wool carpeting is more susceptible to insects and fungus than is synthetic carpeting. Although wool fibers attract more dirt particles than do synthetic fibers, the dirt will not be as noticeable.

What kind of substance is polypropylene?

A. Acrylic
B. Fungal
C. Fused
D. Nylon
E. Synthetic

Level 7

At this level, the questions are similar to those at Level 6 in that they call on the examinee to generalize beyond the stated situation, to recognize implied details, and to recognize the probable rationale behind policies and procedures. However, the passages are more difficult: the density of information is higher, the concepts are more complex, and the vocabulary is more difficult. Passages include jargon and technical terms whose definitions must be derived from context. At this level, passages include excerpts from regulatory and legal documents that are more complicated than those at Level 6.

Example:

(Excerpt)

Section 70.101
When the respirable dust in the atmosphere of the workplace contains more than 5% quartz, the supervisor shall continuously maintain the average concentration of respirable dust in the atmosphere during each shift to which each worker in the active workings is exposed at or below a concentration of respirable dust, expressed in milligrams per cubic meter of air as measured with an approved sampling device and in terms of an equivalent concentration determined in accordance with Section 70.206, computed by dividing the percent of quartz into the number 10. For example, if the respirable dust associated with a mechanized unit or a designated area contains quartz in the amount of 5.1%, the average concentration of respirable dust in the atmosphere associated with that mechanized unit or designated area shall be continuously maintained at or below 1.98 milligrams of respirable dust per cubic meter of air.

Section 70.206 is most likely to include a definition of:

A. active workings.
B. equivalent concentration.
C. mechanized unit.
D. respirable dust.
E. sampling device.

WORKKEYS

Listening and Writing

Test Descriptions

The Listening and Writing assessment measures two distinct but related skills - listening and writing. Both skills are assessed in one test because the skills are used together in the workplace. Employees are often asked to listen to spoken information and then prepare a written document based on that information.

The test is administered via an audiotape which contains all directions and messages. Messages are read by a variety of speakers. Each message is read twice with time given between readings for note-taking. Space is provided in the answer booklet for notes; however, the notes are not scored.

After the message is read a second time, the examinees have a specified time to write the message before the next message is read. Examinees may go back and work on earlier messages if they have time. Written messages are scored for listening based on the accuracy and completeness of information that the examinee has included. The writing is evaluated separately, by a different scorer, based on the quality and appropriateness of the writing sample itself, not on its specific content.

Messages for each level are developed according to the following criteria:

Level 1

Messages contain about six pieces of information.

Example:

[Narrator] You work in a clothing store and receive this telephone message.

[Female voice] This is Amy. Tell Bobby that the sweaters will be delivered on Friday before noon. I know Bobby wanted the sweaters last week, but the sweater company's knitting machine broke down.

Level 2

Messages contain about ten pieces of information.

Example:

[Narrator] You work in a camera store and a customer comes in and gives you this message.

[Female voice] I'm Brenda Garcia and I bought this camera at your store two years ago. I really like it but I dropped it last week and now I am having trouble getting it to flash. Could you have a repair person look at it and call me if they think it can be fixed? Also, how much will it cost to fix it? My telephone number is 699-8824.

Level 3

Messages contain about fourteen pieces of information.

Example:

[Narrator] You work at a plumbing company and receive this telephone message.

[Male voice] Boy, have we got a mess here! The water heater broke and spilled all over everywhere. The carpeting is soaked and so is the wallpaper. I finally figured out how to turn the water off, but before that it was terrible. I need a repair person to come out and fix it right away. I forget what brand it is, but I bought it from you. I'm at 5972 Hawthorne Way. That's H-A-W-T-H-O-R-N-E. 5972. It's a brown house on the corner. My name is Hasegawa. Charles Hasegawa. My telephone number is 889-6836.

Level 4

Messages contain about seventeen pieces of information and involve two speakers.

Example:

[Narrator] You work for a realtor and are to write a summary of what new clients are looking for in a property.

[Female voice] Hi, I'm Anna Starway and this is Greg. We're planning to move to this area soon.

[Male voice] We want to buy about 5 to 15 acres of wooded property, maybe some pasture. If it has pasture, we'll need some kind of barn or building for animals. But the trees are more important.

[Female voice] We want a house on the property, too, not just a building lot. The house can be small since there are just the two of us.

[Male voice] Another thing I would like is a workshop area, either in the house or in another building on the property. Some garden space would be good, too.

[Female voice] Our phone number is 338-3299. We'll be available to look at possibilities on weekends.

Listening Scoring Criteria

The length and complexity of the messages presented for listening increase from Level 1 to Level 4 of this assessment as described below. However, the same criteria are applied in scoring listening at each of the four levels. The scoring criteria are:

Score		Example (all from same Level 3 message)
0	No meaningful information; totally inaccurate message.*	*Please come over and fix my heater. It is a brown house on the corner.*
1	Minimal pertinent information; enough context to provide clues as to gist of message or source of further information.	*Water heater shut off. Don't know what brand. 889-6836.*
2	Some pertinent information; may have incorrect information, but sketch of the situation is correct.	*Charles Hasaga called. His water heater broke and it got stuff wet. He bought a part from us. He's at 5972 Hawthorne, the brown house.*
3	Message substantially correct; may be missing one or two critical pieces of information.	*Charles Hasaga called. He said that the water heater broke. He needs a repairman. His address is 5972 Hawthorne, a brown house on the corner. His number is 889-6836.*
4	Message correct in that all critical information given is correct; may be missing subtle details or tone; may have incorrect noncritical information that does not interfere with central message.	*Please send someone out to 5972 Hawthorne Way. Mr. Charles Hasegawa (phone 889-6836) has a broken water heater. He does have the water turned off, but there is water everywhere. It's a brown house on the corner.*
5	All information correct; all critical information present and correct; message conveys insight into situation through tone and/or subtle details.	*URGENT! Water heater broke at 5972 Hawthorne Way (brown house on corner). Carpet and wallpaper are soaked. Water is turned off, but need a repair person to come fix it right away. Charles Hasegawa (phone 889-6836) does not know the brand name of the heater, but he bought it from us.*

* The following types of responses are noted and receive scores of zero (0):

NR - no response; page is blank.
OT - response is off topic.
NE - response is not in English.
IL - response is illegible.

Writing Scoring Criteria

The length and complexity of the messages presented for writing increase from Level 1 to Level 4 of this assessment as described below. However, the same criteria are applied in scoring writing at each of the four levels. The scoring criteria are:

Score		Example (all from same Level 3 message)
0	No message or garbled message; grossly inappropriate for business setting; no recognizable sentence structure.*	*heter mess now*
1	Message conveyed inadequately; inappropriate for business setting; gross mechanical errors; overall lack of proper sentence structure.	*Water Heater Busted. Name Charles 889-6836.*
2	Message conveyed adequately; moderately acceptable for business setting; large number of mechanical errors; weak sentence structure.	*We have a mess here my water heater broke and I need a repair person out here right away. I bought the brand from you and I dont know the name is. My name is Charles Hasegawa 5972 Hawthorne way brown house on the corner.*
3	Message conveyed clearly; acceptable for business setting; some mechanical errors; most sentences complete.	*Charles Hasegawa called about a broken water heater. Its a real mess and he needs you out there right away. His carpet and wallpaper is soaked. Doesn't know the brand but he bought it from you. He lives on 5972 Hawthorne Way.*
4	Message conveyed clearly; appropriate for business setting; may have a few minor mechanical errors; all sentences are complete; may have choppy style.	*Charles Hasegawa called because his water heater broke and things are a mess. His carpeting and wallpapering are soaked. He figured out how to turn the water off, but he needs a repairman right away. He bought it from us, but is not for sure what brand it is. He lives at 5972 Hawthorne Way.*
5	Message conveyed clearly; highly appropriate for business setting and specific situation; no mechanical errors; good sentence structure; smooth, logical style.	*Attention: Repair Person URGENT!* *A broken water heater and water damage to carpeting and wallpaper at the home of Charles Hasegawa, 5972 Hawthorne Way, require immediate attention. The water is turned off, so further damage should not occur. Mr. Hasegawa says that he bought the water heater here, but he is unable to remember the brand name. The house is brown and on the corner; if you need further information, his telephone number is 889-6836.*

* The following types of responses are noted and receive scores of zero (0):

NR - no response; page is blank.
OT - response is off topic.
NE - response is not in English.
IL - response is illegible.

Messages for each level are developed according to the following criteria:

Level 1

Messages contain about six pieces of information.

At least one complete sentence is to be written within two minutes.

Example:

[Narrator] You work in a clothing store and receive this telephone message.

[Female voice] This is Amy. Tell Bobby that the sweaters will be delivered on Friday before noon. I know Bobby wanted the sweaters last week, but the sweater company's knitting machine broke down.

Level 2

Messages contain about ten pieces of information.

One or more complete sentences are to be written within two minutes.

Example:

[Narrator] You work in a camera store and a customer comes in and gives you this message.

[Female voice] I'm Brenda Garcia and I bought this camera at your store two years ago. I really like it but I dropped it last week and now I am having trouble getting it to flash. Could you have a repair person look at it and call me if they think it can be fixed? Also, how much will it cost to fix it? My telephone number is 699-8824.

Level 3

Messages contain about fourteen pieces of information.

At least one paragraph is to be written within four minutes.

Example:

[Narrator] You work at a plumbing company and receive this telephone message.

[Male voice] Boy, have we got a mess here! The water heater broke and spilled all over everywhere. The carpeting is soaked and so is the wallpaper. I finally figured out how to turn the water off, but before that it was terrible. I need a repair person to come out and fix it right away. I forget what brand it is, but I bought it from you. I'm at 5972 Hawthorne Way. That's H-A-W-T-H-O-R-N-E. 5972. It's a brown house on the corner. My name is Hasegawa. Charles Hasegawa. My telephone number is 889-6836.

Level 4

Messages contain about seventeen pieces of information and two speakers are involved.

One or more paragraphs are to be written within seven minutes.

Example:

[Narrator] You work for a realtor and are to write a summary of what new clients are looking for in a property.

[Female voice] Hi, I'm Anna Starway and this is Greg. We're planning to move to this area soon.

[Male voice] We want to buy about 5 to 15 acres of wooded property, maybe some pasture. If it has pasture, we'll need some kind of barn or building for animals. But the trees are more important.

[Female voice] We want a house on the property, too, not just a building lot. The house can be small since there are just the two of us.

[Male voice] Another thing I would like is a workshop area, either in the house or in another building on the property. Some garden space would be good, too.

[Female voice] Our phone number is 338-3299. We'll be available to look at possibilities on weekends.

WORKKEYS

Applied Mathematics

Test Description

The Applied Mathematics assessment is a test of mathematical problem-solving that focuses on mathematical reasoning skills generally required in the workplace. The test questions draw out examinee skills in solving calculation problems and in setting up and solving work problems. This test is designed to be taken with a calculator. As on the job, the calculator serves as a tool in the process of problem solving. A formula sheet that includes, but is not limited to, all required formulas is also provided (see page 20).

The test contains questions at five levels of difficulty with Level 3 being the easiest. Higher levels of difficulty assume the examinee is knowledgeable of the skills assessed in lower levels.

Level 3

Problems at Level 3 involve minimal translation between their verbal and mathematical equivalents. These problems focus on basic mathematical operations (addition, subtraction, multiplication, and division) performed on whole numbers, fractions, decimals, or percentages. Units of measurement may be included in problems; however, with the exception of dollars and cents, units function solely as labels and are not involved in actual calculations.

Solutions to problems in Level 3 are generally straightforward, involving a single type of mathematical operation. For example, the examinee might be required to add several numbers or calculate the correct change in a simple transaction. All the information needed to solve the problems is provided in logical order; no unrelated information is included.

Examples:

In your job as a cashier, a customer gives you a $10 bill for a can of coffee that costs $3.84. How much change should you give back?

A. $5.26
B. $6.16
C. $6.84
D. $7.16
E. $7.84

The angle of the saw that you operate is now set at -25°. If you must increase the angle by 30°, to what angle must you set the saw?

A. - 5°
B. 0°
C. 5°
D. 25°
E. 30°

Level 4

Problems at Level 4 may involve performing one or two mathematical operations. These may include addition, subtraction, or multiplication of several positive or negative numbers. (Division of negative numbers, however, is not covered until Level 5.) Addition of commonly known decimals, fractions, or percentages (e.g., 25%, ½, .75) may be covered, as may addition of three fractions that share a common denominator.

At this level, the examinee may be required to calculate averages, simple ratios, proportions, and rates using whole numbers or decimals. These problems may require examinees to read a simple chart or graph (e.g., a histogram) to obtain the information needed for a solution. Additionally, solutions to problems at Level 4 may require the examinee to reorder verbal information before performing calculations.

Examples:

What is the average of 33, 29, 38, 28, and 40 ?

A. 29.5
B. 32.0
C. 33.0
D. 33.6
E. 35.4

It takes you about 1.5 hours to set up a computer workstation. At this rate, how many hours will it take to set up 6 of these workstations?

A. 0.25
B. 6.00
C. 7.50
D. 9.00
E. 9.75

Level 5

Problems at Level 5 may contain several steps of logic and calculation, but the problems are well defined and the values required by the problems are given. Examples of such problems include comparison of alternatives to determine the one that best meets a stated condition and completion of a balance sheet or order form.

Problems may require the examinee to look up and calculate single-step conversions within English or non-English systems of measurement (e.g., calculating with ounces and pounds or centimeters and meters). Also assessed at this level is the ability to calculate using mixed units (e.g., hours and minutes).

Examples:

Quik Call charges 18¢ per minute for long-distance calls. Econo Phone totals your phone usage each month and rounds the number of minutes up to the nearest 15 minutes. It then charges $7.90 per hour of phone usage, dividing this charge into 15 minute segments if you use less than a full hour. If your office makes 5 hours 3 minutes worth of calls this month using the company with the lower price, how much will these calls cost?

A. $39.50
B. $41.48
C. $41.87
D. $54.00
E. $54.54

You have been asked to ship a package that weighs 41 pounds; however, the freight company's form requires the weight in kilograms. What is the closest approximation of the weight of the package in kilograms? (Note: the conversion formula is provided to the examinee on the formula sheet.)

A. 18.64
B. 43.20
C. 82.00
D. 90.20
E. 100.00

Level 6

Problems at Level 6 may require considerable translation from verbal form to mathematical expression. They generally require considerable setup and involve multiple steps of calculation or conversion. Negative numbers, fractions, ratios, percentages, and mixed numbers are commonly used in problems at this level.

Included in this level are calculations of multiple rates, areas of rectangles or circles, and volumes of rectangular solids. The examinee may be required to transpose a formula before calculating or to look up and use two formulae in conversions within a system of measurement.

Level 6 problems may also involve identifying and correcting errors made in problems at lower levels ("trouble-shooting").

Examples:

You are preparing to tile the floor of a rectangular room that is 15.5 feet by 18.5 feet in size. The tiles that you plan to use are squares that measure 12 inches on each side, and are sold in boxes that contain enough tile to cover 25 square feet. How many boxes of tiles must you order to complete the job?

A. 11
B. 12
C. 24
D. 59
E. 287

The production line where you work can assemble 5 amplifiers every 30 minutes. At this rate, how long will it take the line to assemble 125 of the amplifiers?

A. 4 hours 10 minutes
B. 12 hours 30 minutes
C. 12 hours 50 minutes
D. 20 hours 50 minutes
E. 25 hours

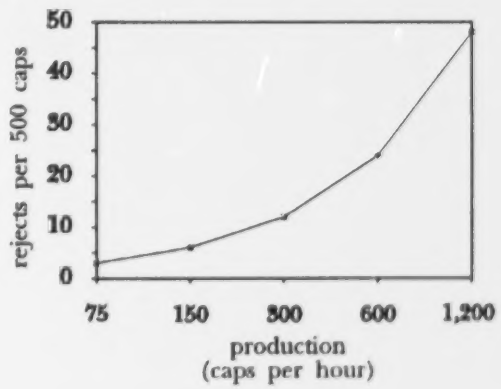
Level 7

Problems at this level require multiple steps of logic and calculation. The content or format may be unusual, and the information presented may be incomplete or implicit, requiring the examinee to derive the information needed to solve the problem. Conversions between systems of measurement that involve fractions, mixed numbers, decimals, or percentages are required at this level.

Nonlinear functions (e.g., rate of change), problems with more than one unknown, and applications of basic statistical concepts (e.g., error of measurement) may be involved. Also included at this level are problems involving calculation of multiple areas and volumes of spheres, cylinders, and cones, as well as trouble-shooting of Level 6 problems.

Examples:

You operate a machine that stamps bottle caps out of 3-inch-by-3-inch aluminum squares. Occasionally, the machine produces an unusable cap, a reject, that must be recycled. The number of rejects made at different production rates is shown below. Today you have been told to produce 600 caps per hour. Approximately how many caps total will you have to produce to end up with your quota of 2,400 good ones?



A. 2,400
B. 2,448
C. 2,516
D. 2,548
E. 2,616

Your company makes bowling balls using a plastic resin. The balls are made by melting the resin and injecting it into a mold. (The finger holes are drilled out of the solid ball after it cools.) Which of the following is the best approximation of the volume of resin required to make a ball with a radius of 4 inches?

A. 16 cubic inches
B. 50 cubic inches
C. 66 cubic inches
D. 150 cubic inches
E. 268 cubic inches

WORKKEYS

Units of measurement

Distance
1 foot = 12 inches
1 yard = 3 feet
1 mile = 5,280 feet
1 mile ≈ 0.621 kilometers
1 inch ≈ 2.540 centimeters
1 foot ≈ 0.3048 meters
1 meter = 1,000 millimeters
1 meter = 100 centimeters
1 kilometer = 1,000 meters

Area
1 square foot = 144 square inches
1 square yard = 9 square feet
1 acre = 208.71 feet square
1 acre = 43,560 square feet

Volume
1 cup = 8 fluid ounces
1 quart = 4 cups
1 gallon = 4 quarts
1 gallon = 231 cubic inches
1 liter ≈ 0.264 gallons
1 cubic foot = 1,728 cubic inches
1 cubic yard = 27 cubic feet
1 board foot = 1 inch by 12 inches by 12 inches

Weight
1 ounce ≈ 28.350 grams
1 pound = 16 ounces
1 pound ≈ 453.593 grams
1 milligram = 0.001 grams
1 kilogram = 1,000 grams
1 kilogram ≈ 2.2 pounds
1 ton = 2,000 pounds

Temperature

$°C = .56(°F - 32)$ or $\frac{5}{9}(°F - 32)$

$°F = 1.8(°C) + 32$ or $(\frac{9}{5} \times °C) + 32$

Electricity
1 kilowatt-hour = 1,000 watt-hours

Formulas

Rectangle
perimeter = $2(length + width)$
area = $length \times width$

Cube
volume = length of side^3

Triangle
sum of angles = 180°

area = $\frac{1}{2}(base \times height)$

Circle
circumference = 360°
circumference ≈ $3.14 \times diameter$
area ≈ $3.14 \times radius^2$

Cylinder
volume ≈ $3.14 \times radius^2 \times$ height

Cone

$$\text{volume} \approx \frac{3.14 \times (radius)^2 \times height}{3}$$

Ball

$$\text{volume} \approx \frac{4}{3} \times 3.14 \times radius^3$$

Amperage
amps = watts ÷ volts

Resistance

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_n} \quad \text{parallel circuits}$$

$$\frac{1}{R_{total}} = R_1 + R_2 + \ldots R_n \quad \text{series circuits}$$